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NATIONAL DAM SAFETY PROGRAM. GOVRO LAKE DAM (MO 31095), MISSISS--ETC(U)
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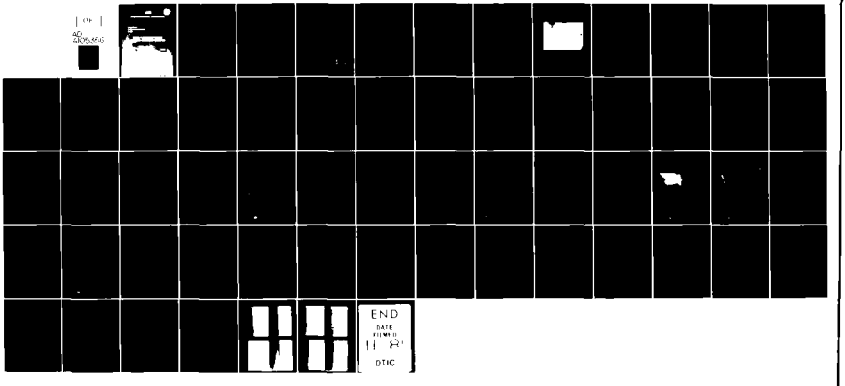

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18. SUPPLEMENTARY NOTES

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-PD

SUBJECT: Govro Lake Dam Phase I Inspection Report
(MO No. 31095)

This report presents the results of field inspection and evaluation of the Govro Lake Dam (MO No. 31095). It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED
Chief, Engineering Division

21 JUL 1981
Date

APPROVED BY: SIGNED
Colonel, CE, Commanding

23 JUL 1981
Date

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MISSISSIPPI - KASKASKIA - ST LOUIS RIVER BASIN

GOVRO LAKE DAM

STE. GENEVIEVE COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31095

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

APRIL 1981

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Govro Lake Dam
State Located: Missouri
County Located: Ste. Genevieve
Stream: Tributary of South Cabouri Creek
Date of Inspection: January 29, 1981

Govro Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately five miles downstream of the dam. Located within this zone are several dwellings, a pond, a farm, a railroad overpass and a railroad terminal.

The dam is in the intermediate size classification, since it is greater than 40 ft high but less than 100 ft high.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway flow line is at a higher elevation than the low point of the embankment. The dam will store 90 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream hazard potential pass 100 percent of the PMF.

The 100 year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

The embankment was in good condition. Deficiencies visually observed by the inspection team were: (1) vertical alignment of embankment crest uneven; (2) scattered tree and bush growth on upstream and downstream slopes; (3) lack of permanent control section provided for principal spillway; (4) lack of wave protection for the upstream embankment face; and (5) top of dam elevation lower than principal spillway crest.

Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom R. Beckley, P.E.
Anderson Engineering, Inc.

Dave Daniels, P.E.
Hanson Engineers, Inc.

Gene Wertepny, P.E.
Hanson Engineers, Inc.

AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
GOVRO LAKE DAM
MISSOURI INVENTORY NO. 31095

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APPENDICES

SECTION 1 PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Govro Lake Dam in Ste. Genevieve County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Govro Lake Dam is an earth fill structure approximately 45 ft high and 1050 ft long at the crest. The appurtenant work consists of an earthcut principal spillway channel.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments. Sheet 4 of Appendix A shows a cross-section and profile of the principal spillway. Sheet 5 of Appendix A is a plan sketch of the dam.

B. Location:

The dam is located in the Northeastern part of Ste. Genevieve County, Missouri on a tributary of South Cabouri Creek. The dam and lake are within the STE. Genevieve, Missouri - Illinois 7.5 minute quadrangle sheet (Section 2, T37N, R8E latitude 37°56.8'; longitude 90° 07.0'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 45 ft and a maximum storage capacity of approximately 113 acre-ft, the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has determined that this dam is in the high hazard ptoential classification. The estimated damage zone extends approximately five miles downstream of the dam. Located within this zone are several dwellings, a pond, a barn, a railroad overpass and a railroad terminal. The affected features within the damage zone were verified by the inspection team.

E. Ownership:

The dam is owned by Mrs. Egar Govro.
The owner's address is RFD 2, Box 21, Ste. Genevieve, Missouri.

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

Construction of the dam was started in 1964 and completed in 1968. Mr. Edgar Govro (deceased) constructed the dam. All information relative to the dam was obtained from conversations with Mrs. Edgar Govro.

Mrs. Govro stated that a core trench was excavated along the centerline of the embankment. The material for the embankment and core trench was obtained from the lake bed area.

No design or engineering drawings were prepared for the construction of the dam. All layout dimensions of the embankment and spillway were set by Mr. Govro.

Mrs. Govro indicated that during construction, numerous outcroppings of rock were exposed in the lake bed. After completion of the dam, Mrs. Govro stated that the lake level remained essentially about 3 or 4 feet above the bottom of the lake. Two years after the dam was completed, Mrs. Govro stated than an unknown quantity of concrete was placed around some outcroppings of rock near the bottom of the lake. The repair procedure resulted in raising the normal maintained pool to its present elevation of 637.0. No additional repairs have been attempted to raise the pool level. The owner stated that the downstream area was walked numerous times in an effort to locate water egress. No apparent point of egress has been located to date.

H. Normal Operating Procedures:

The dam was designed for flows to be passed by the uncontrolled earthcut spillway at the North abutment. The flow line of the spillway is 1.6 feet above the lowest elevation of the dam (Station 4+00). Consequently, all flows would be passed over the embankment crest. Mrs. Govro stated that the dam had never been overtopped. She further stated the maximum water level she recalls was about 20 feet below the top of the dam.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 32 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through overtopping of the embankment crest (Station 4+00).

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of dam El. 666.0): 0 cfs

(3) Estimated Capacity of Principal Spillway: 255 cfs at elevation 670.0.

(4) Estimated Capacity of Emergency Spillway: Not applicable.

(5) Estimated Experience Maximum Flood at Dam Site: Elevation 646.6 (High water, no flow).

(6) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable.

(7) Diversion Tunnel Outlet at Pool Elevation: Not Applicable.

(8) Gated Spillway Capacity at Pool Elevation: Not Applicable.

(9) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable.

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 670.0 for top of house floor slab, station 0-70, 75 feet left of centerline of dam (estimated from quadrangle map).

(1) Top of Dam: 666.00 feet, MSL (Low Point); 669.5 feet, MSL (High Point)

(2) Principal Spillway Crest: 667.6 feet, MSL

(3) Emergency Spillway Crest: Not Applicable

(4) Principal Spillway Pipe Invert at Outlet: Not Applicable

(5) Streambed at Centerline of Dam: 626.0 feet, MSL

(6) Pool on Date of Inspection: 637.0 feet, MSL

(7) Apparent High Water Mark: 646.6 feet, MSL

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 600 feet

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 620 feet

E. Storage Capacity:

(1) At Top of Dam: 113 Acre-Foot

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 125 Acre-Foot

F. Reservoir Surface Areas:

(1) At Top of Dam: 6.8 Acres

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 7.2 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 1050 feet

(3) Height: 45 feet

(4) Top Width: 9 feet

(5) Side Slopes: Upstream varies from 1V on 3.2 H to 1V on 3.5 H
Downstream varies from 1V on 2.0 to 1V on 2.5 H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: None

(8) Cutoff: Key trench, depth unknown

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: North Abutment

(2) Type: Earthcut Channel

(3) Upstream Channel: Earth and Rock Outcropping Channel

(4) Downstream Channel: Earthcut Channel

I.2 Emergency Spillway:

(1) Location: Not Applicable

(2) Type: Not Applicable

(3) Upstream Channel: Not Applicable

(4) Downstream Channel: Not Applicable

J. Regulating Outlets: There are not regulating outlets with this dam.

SECTION 2 ENGINEERING DATA

2.1 DESIGN

There were no design calculations or engineering drawings prepared for the dam. No documentation of construction inspection records were available. There are no documented maintenance data.

A. Surveys:

No pre-construction survey data was available. The survey data for construction of the dam was set by Mr. Govro.

Sheet 3 of Appendix A presents a plan, profile and cross-section of the dam from survey data obtained during our site inspection. The top of the house floor slab at station 0-70 was used for our site datum. The mean sea level elevation of 670.0 for our site datum was estimated from the Ste. Genevieve, Missouri-Illinois 7.5 minute quadrangle sheet.

B. Geology and Subsurface Materials:

The site is located along the Eastern edge of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists of the Plattin and Decorah formations. The Plattin consists of evenly bedded, dark gray, finely crystalline to sublithographic limestone which contains minor amounts of intercolated shale. The Decorah consists of green or brown shales and has numerous, thin, interbedded limestone layers in its lower part that grade upward into a medium to thinly bedded, fossiliferous limestone which contains thin, fossiliferous shale partings. The U.S.G.S. quad sheet indicates several sinkholes in the area.

The "Geologic Map of Missouri: indicates several normal faults located west of the site. The site is located in seismic zone 2 (moderate damage zone) but is close to the boundary of zone 3 (major damage zone, see sheet 3 of Appendix B).

Examination of the site indicated a fairly thin soil cover. Limestone bedrock was exposed in the lake area and close to the crest of the dam in the spillway area. The soils are of the Menfro - Winfield - Soil Association and have developed from thick loess deposits (see Loessial Thickness Map, sheet 2 of Appendix B). Auger probes in the embankment indicate the soils to be reddish-brown clayey silts to silty clays (ML-CL).

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analysis apparently were not performed as required in the Corps of Engineering guidelines. The owner indicated that a core trench, unknown width and depth, was excavated to a clay base. All embankment fill material was obtained from the lake bed area.

D. Hydrology and Hydraulics:

No hydrologic and hydraulic design computations are available for this dam. Based on field measurements of spillway dimensions and embankment elevations and the watershed area, lake area and storage data from U.S.G. S. quadrangle sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C.

E. Structure:

There are no structures associated with this dam.

2.2 CONSTRUCTION:

No construction inspection data are available.

2.3 OPERATION:

Normal flows, if the lake were capable of maintaining a full pool, would be passed over the embankment crest near the center of the dam. The elevation of the principal spillway flow line is 1.6 feet higher than the low point of the crest of the embankment.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data was available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment is available.

SECTION 3 VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on January 29, 1981. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven L. Brady Anderson Engineering, Inc. (Civil Engineer)
Tom R. Beckley Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels Hanson Engineers, Inc. (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The embankment appears to be in good condition with grass cover noted on the upstream and downstream slopes of the embankment. The 9 foot wide crest of the embankment was grass covered. The embankment was constructed with a gentle sweeping curve downstream of the lake. The vertical alignment along the crest was irregular, sloping downward from the abutments to the center of the dam. Near the center of the embankment a definite low area was noted (see sheet 3 of Appendix A). The elevation of the top of dam varied from 669.5 (North abutment) to 666.0 (Station 4+00). The low point of the crest, elevation 666.0, was 1.6 feet below the principal spillway crest, elevation 667.6.

The slopes of the embankment were relatively constant. The upstreams slope varied from 1V on 3.2 H to 1V on 3.5 H. The downstream slope varied from 1V on 2.0 H to 1V on 2.5 H. No surface cracking of the embankment was noted. The junctions of the embankment and the abutements appeared good. No significant erosion, sloughing or other unusual movements were noted. No animal burrows were observed.

Small trees and brush growths were observed on the upstream slope at and slightly above normal pool elevation (elevation 637.0). Scattered small tree growths were observed on the upstream and downstream slopes of the embankment.

No riprap was noted along the upstream slope. Due to the low pool level of the dam, erosion from wave action is not a problem. A number of large rocks, 2 to 3 feet in diameter, were noted along the upstream slope.

No seepage or point of water egress from the purported lake leakage was observed.

No instrumentation (monuments, piezometers, etc.) was observed.

Shallow auger probes in the crest of the embankment indicate the soil to be a reddish-brown silty clay (ML to CL).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway is an earthcut channel located at the junction of the embankment and the North abutment. The control section of the spillway is gravel-covered. The spillway has never carried any flow due to the lake not filling and the spillway crest is 1.6 feet higher than the low point of the dam. No nonerodible control section for the spillway was provided.

C.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D. Reservoir:

The watershed is primarily pastureland with rolling to moderate slopes. No significant erosion or sloughing was noted. No significant siltation was noted and it not considered to be a problem. Considerable rock outcropping has been exposed within the reservoir area. The rock was exposed during construction of the dam.

E. Downstream Channel:

The downstream channel is generally tree lined with a well defined channel. The side slopes are gentle to rolling.

3.2 EVALUATION:

The embankment is in good structural condition. Trees and brush on the dam constitute a potential hazard and encourage animal burrowing. The lack of nonerodible control section for the spillway and lack of wave protection for the upstream slope of the embankment could seriously affect the structural stability of the dam. Discharge over the embankment at the low point of the dam could create a potential hazard and affect the embankment stability.

SECTION 4 OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with the dam. The pool level is normally controlled by rainfall, runoff, evaporation and apparent leakage from the reservoir. The owner reported the pool level has never reached the top of the dam. No discharge has been carried by the spillway section which is 1.6 feet above the low point elevation of the embankment.

4.2 MAINTENANCE OF DAM:

No scheduled maintenance of the dam is known to be provided.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The tree and brush growth on the dam, apparent leakage from the reservoir, lack of wave protection, lack of a nonerodible control section for the spillway and the potential discharge over the embankment rather than through the spillway section are deficiencies which should be corrected. Remedial measures should be investigated by an engineer experienced in the design and construction of dams.

SECTION 5 HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner stated that the dam has never been overtopped. The apparent high water line was at elevation 646.6 (top of dam elevation is 666.0). Our hydrologic and hydraulic analyses using Army Corps of Engineers guidelines appears in Appendix C.

C. Visual Observations:

The crest of the principal spillway is 1.6 feet above the low point of the dam. Overtopping of the dam would occur before any discharge is carried by the spillway. The approach to the spillway is clear. The leakage of the reservoir appears to be the major factor in the low normal pool level. The principal spillway channel is well separated from the embankment, and if used, spillway releases would not be expected to endanger the dam. The downstream channel is well defined with tree and brush growth noted.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and HEC1 computer program) were based on: (1) a field survey of spillway dimensions and embankment evaluations; and (2) an estimate of the reservoir storage and pool and drainage areas from the Ste. Genevieve, Missouri-Illinois 7.5 Minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the dam will store 90 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. The dam will store a 1 percent probability flood.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 910 cfs. For 50 percent of the PMF, the peak inflow was 460 cfs.

The routing of 50 percent of the PMF indicates that this inflow will all be stored within the lake. The peak lake elevation for 50 percent of the PMF would be 662.3 (top dam elevation is 666.0). The routing of the PMF indicates the dam will be overtopped by 0.9 feet at elevation 666.0. The maximum outflow over the dam will be 370 cfs, and the duration of overtopping will be 8.5 hours. No outflow will be carried by the spillway (crest elevation of 667.6). Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The only reported post-construction change to the dam was the attempted concrete repairs to stop the leakage from the reservoir.

E. Seismic Stability:

The structure is located in seismic zone 2. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

SECTION 7 ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) Irregular vertical alignment of embankment (2) Top of dam elevation lower than principal spillway crest (3) Scattered tree and brush growth on embankment (4) Lack of permanent control section provided for principal spillway and (5) lack of wave protection for upstream slope.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 90 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions.

The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished without undue delay. If the deficiencies listed in Paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 2. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) Brush and tree growth should be removed from the embankment. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(3) The leakage should be investigated by a professional engineer experienced in the design and construction of dams. Remedial measures may be required.

(4) Wave protection, such as riprap, should be provided for the upstream face of the embankment.

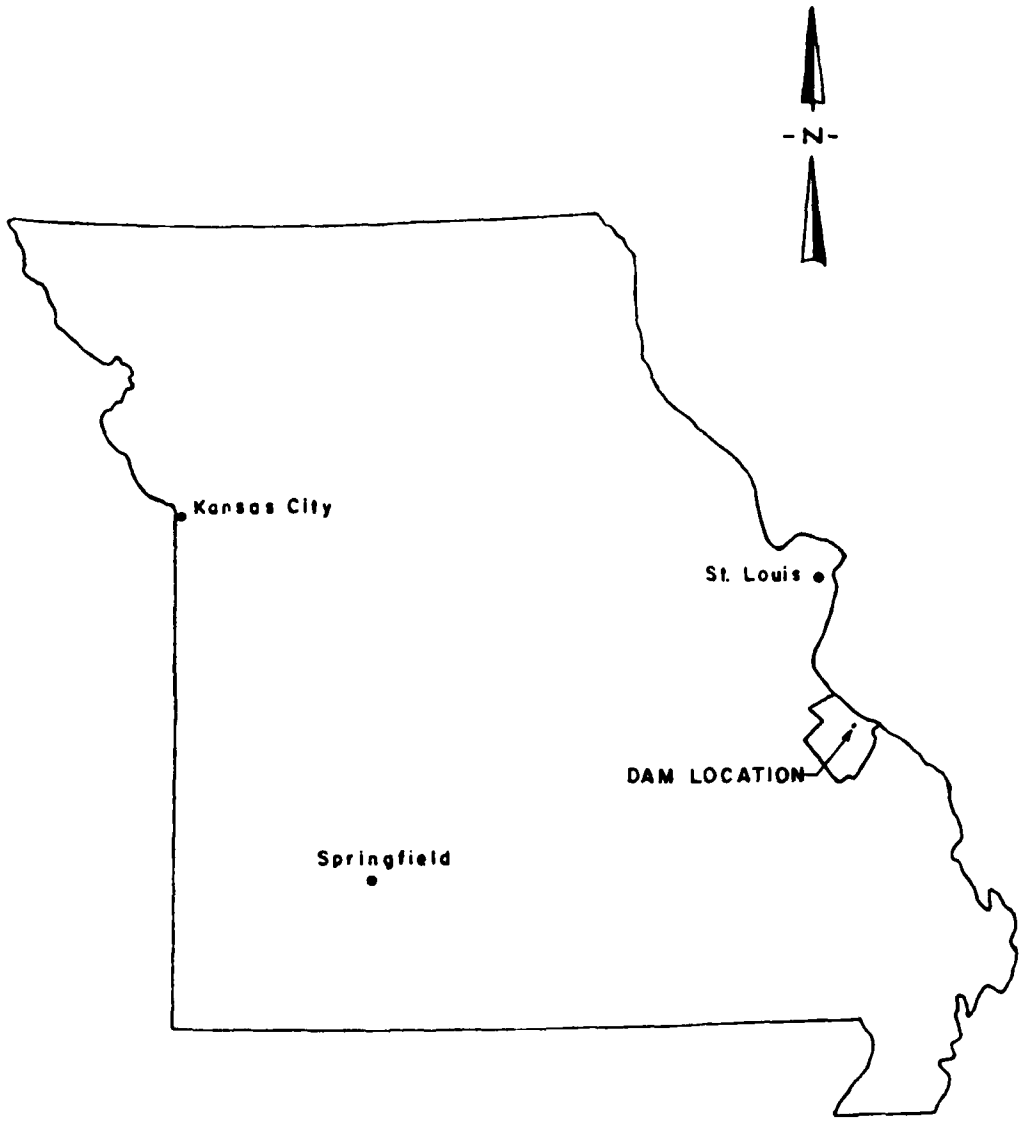
(5) A nonerodiable control section should be provided for the principal spillway.

(6) The irregular vertical alignment of the embankment should be corrected. As a minimum, the embankment elevation and/or spillway elevation should be corrected to have discharges carried through the spillway section.

(7) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



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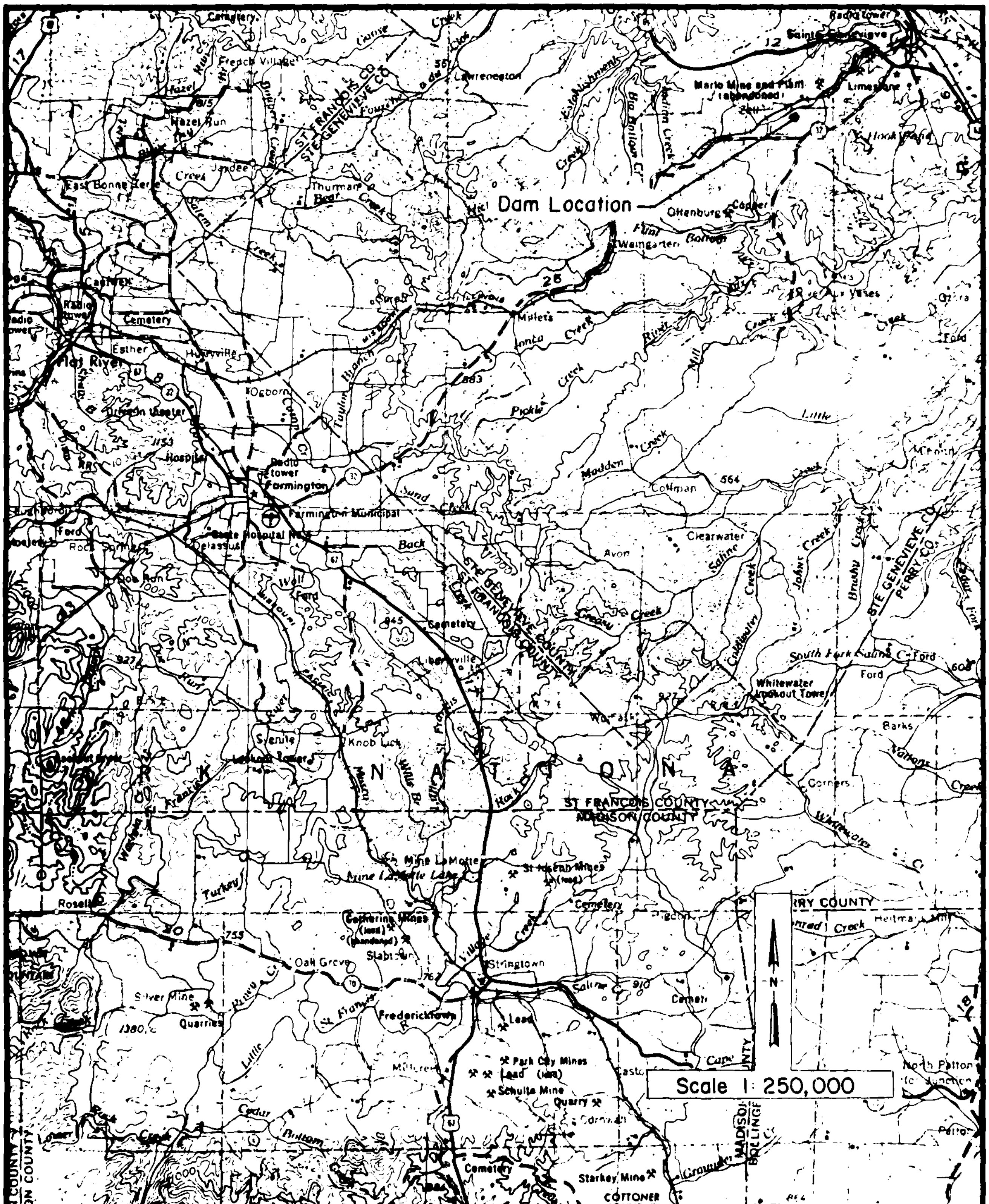
730 N. BENTON AVE. • SPRINGFIELD, MO. 65802

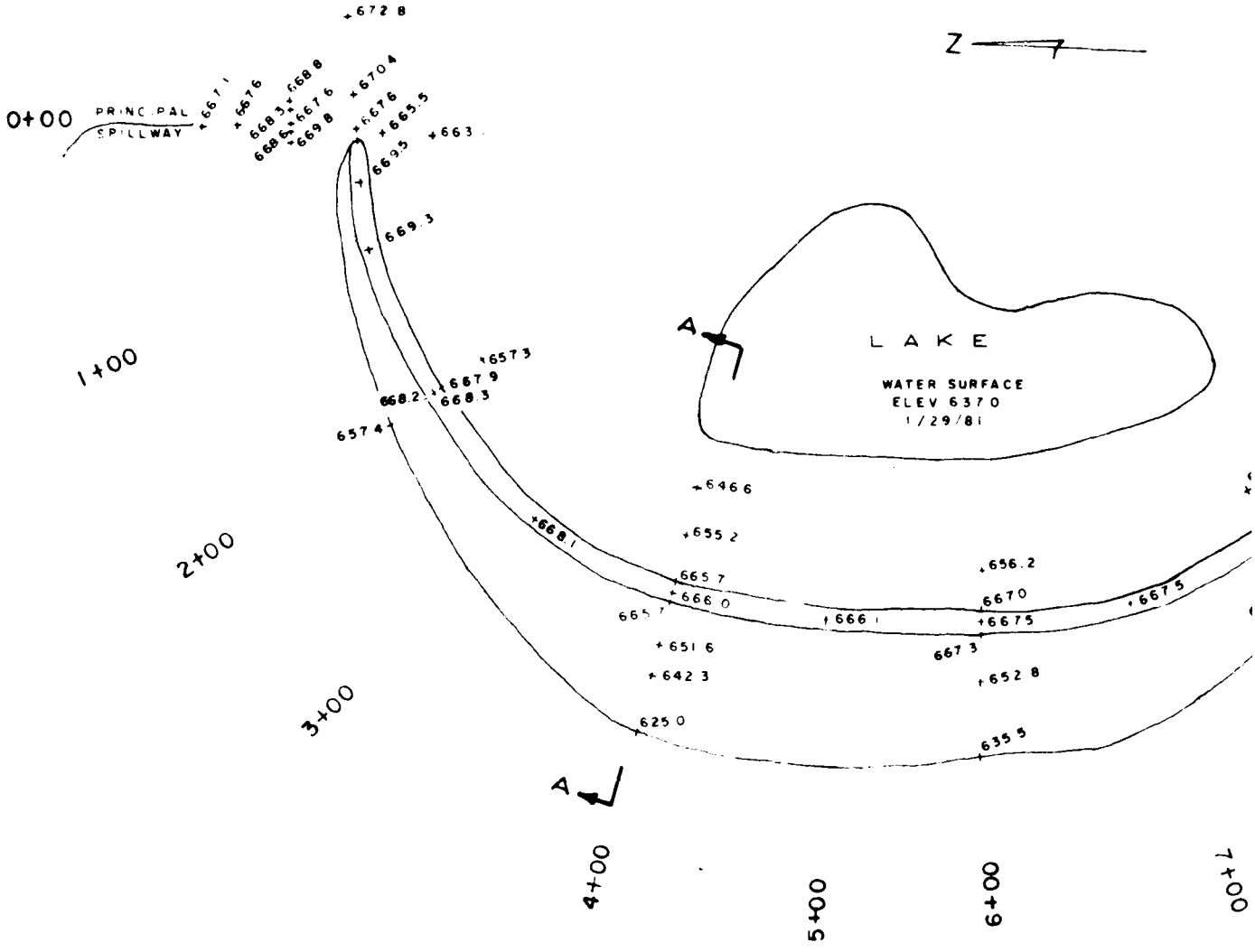
LOCATION MAP

GOVRO LAKE DAM
STE. GENEVIEVE COUNTY, MISSOURI
MO. I. D. No. 31095

SHEET 1, APPENDIX A

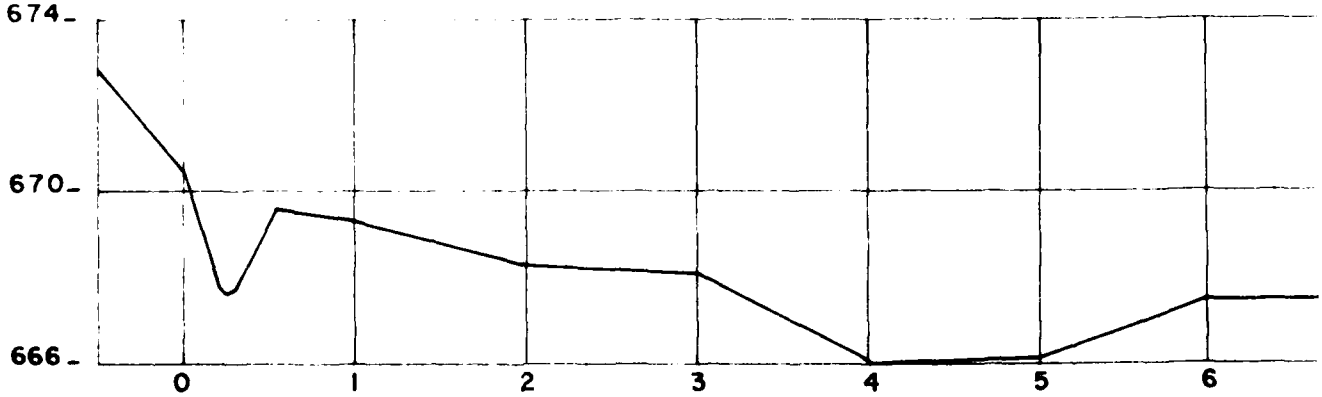


VICINITY MAP	Govro Lake Dam St. Genevieve County, Missouri Mo. I.D. No. 31095
HANSON ENGINEERS INCORPORATED SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL	Sheet 2, Appendix A

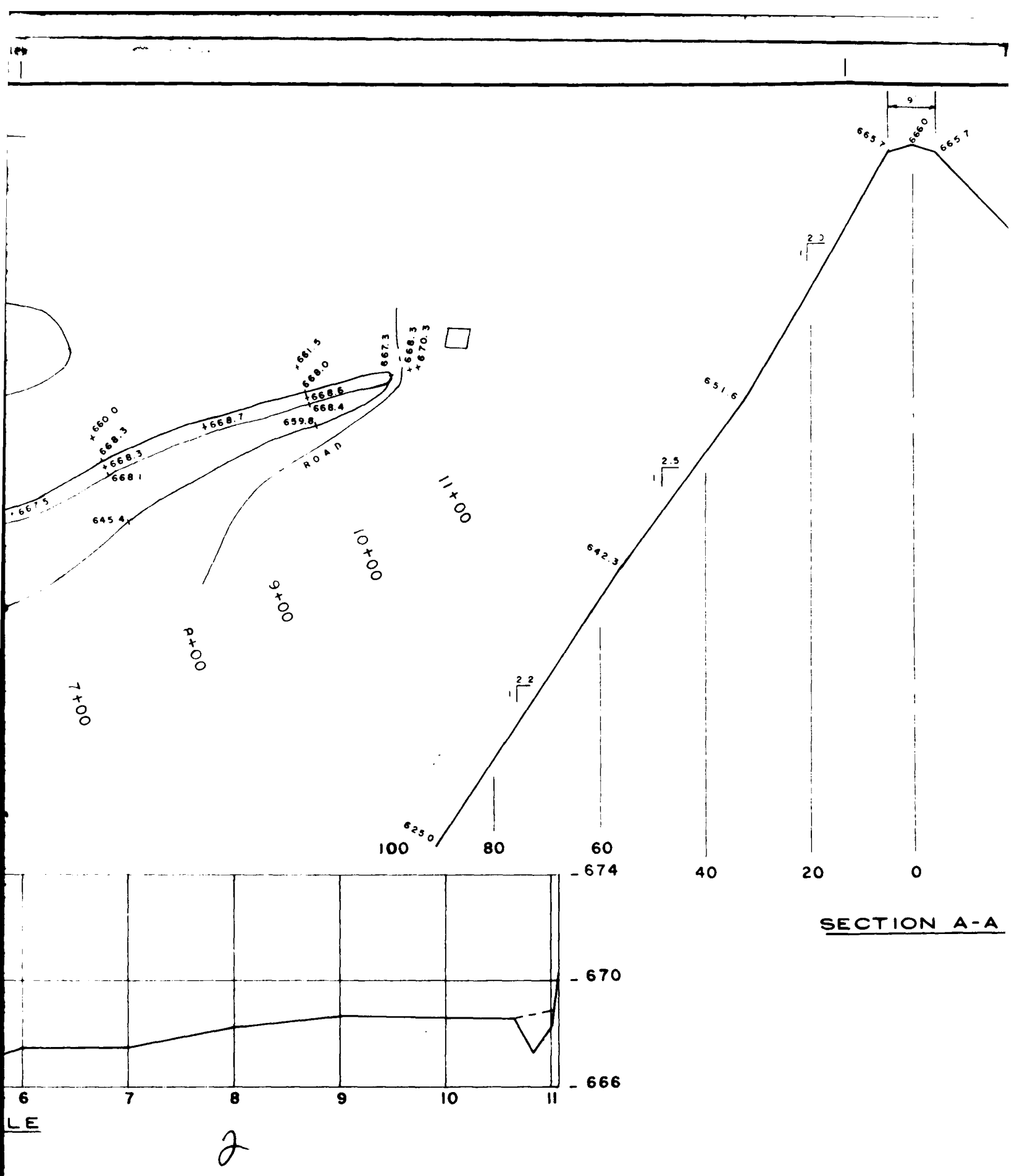


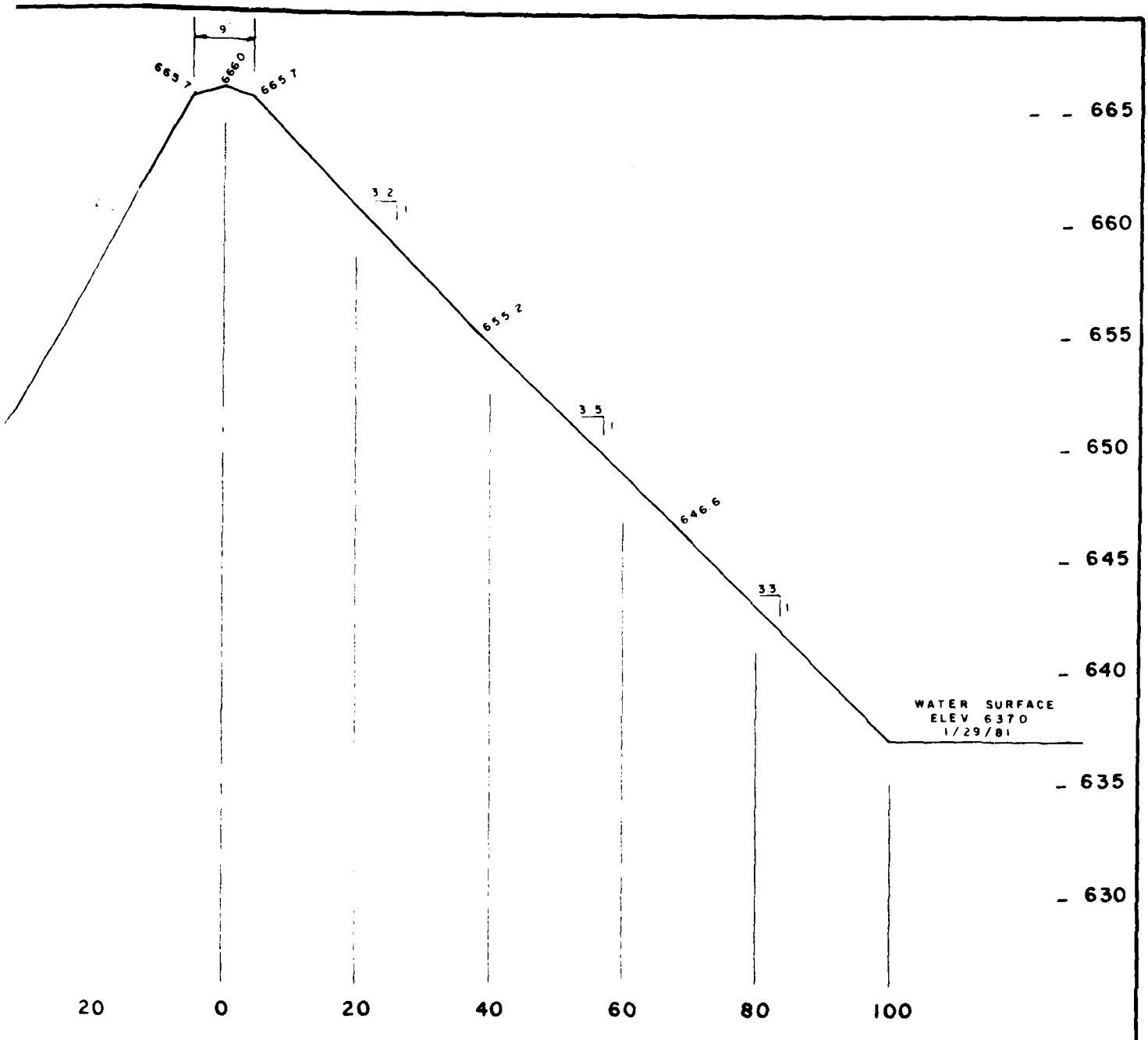
PLAN VIEW
SCALE: 1" = 100'

BENCHMARK:
TOP OF HOUSE FLOOR SLAB
STA 0-70, 75ft. LEFT
ELEV. 670.0 M.S.L.



CENTERLINE PROFILE


9
665.7
666.0
665.7
2.0
651.6
2.5
642.3
2.2
625.0
100
80
60
40
20
0
SECTION A-A
667.3
668.3
670.3
661.5
668.0
668.6
668.4
659.8
668.7
660.0
668.3
668.3
668.1
667.5
645.4
ROAD
11+00
10+00
9+00
8+00
7+00
674
670
666
6
7
8
9
10
11



SECTION A-A STA 4+00

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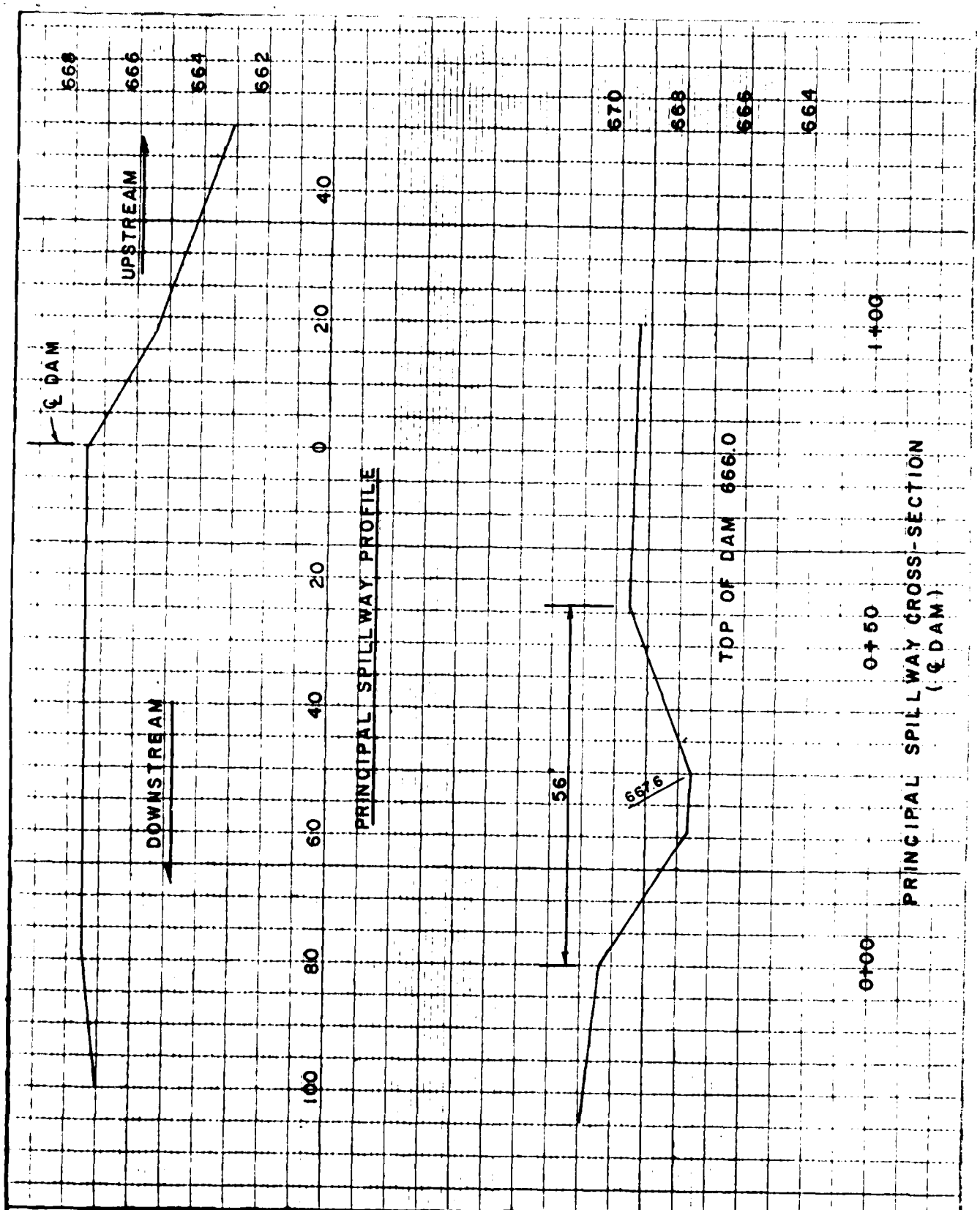
GOVRO LAKE DAM

MO. No. 31095
PLAN, PROFILE AND SECTION OF DAM

STE. GENEVIEVE COUNTY, MISSOURI

SHEET 3, APPENDIX A

3



A/E ANDERSON ENGINEERING, INC.

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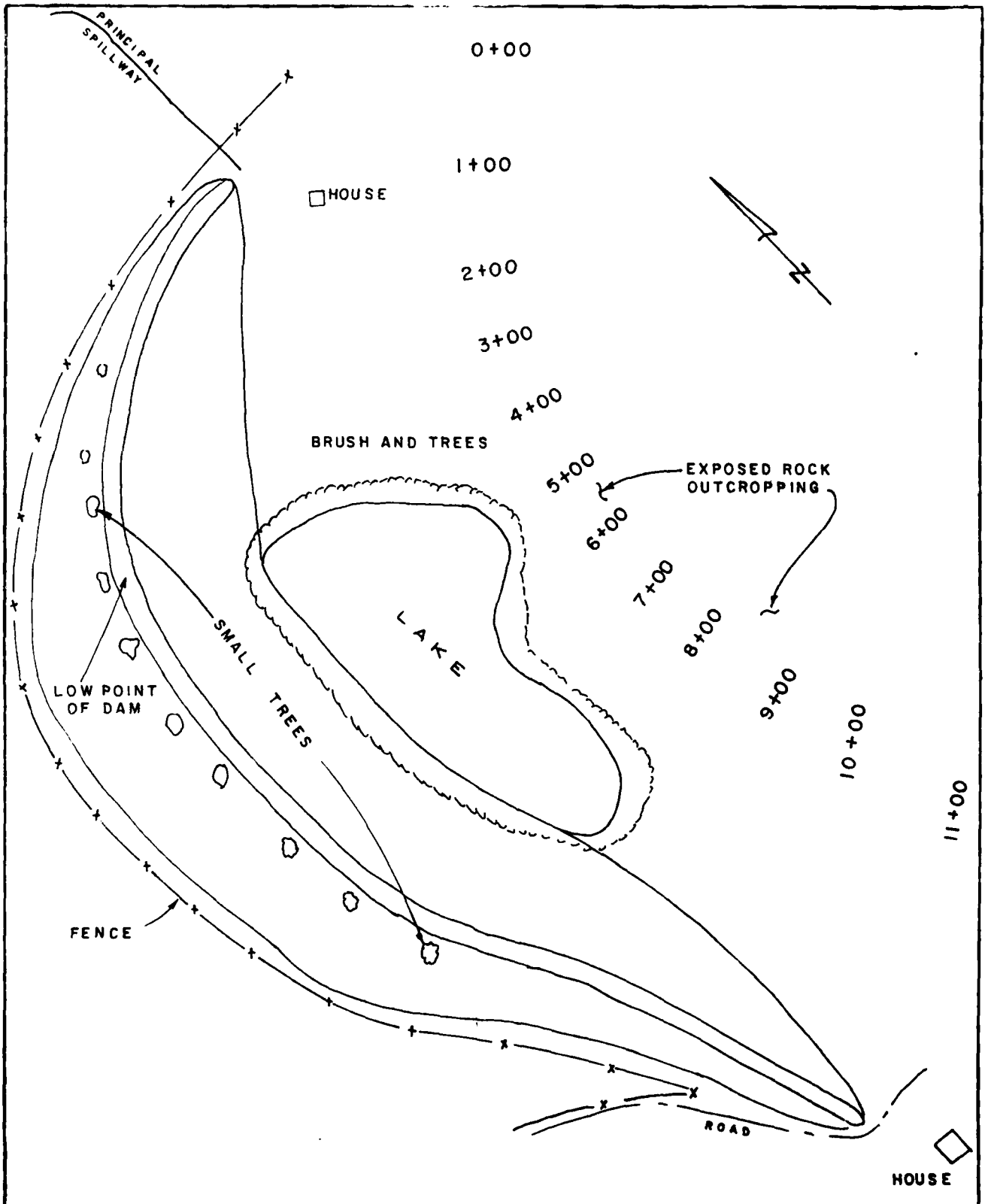
PROFILE & SECTION OF SPILLWAY

GOVRO LAKE DAM

STE. GENEVIEVE COUNTY, MISSOURI

MO. I. D. No. 31095

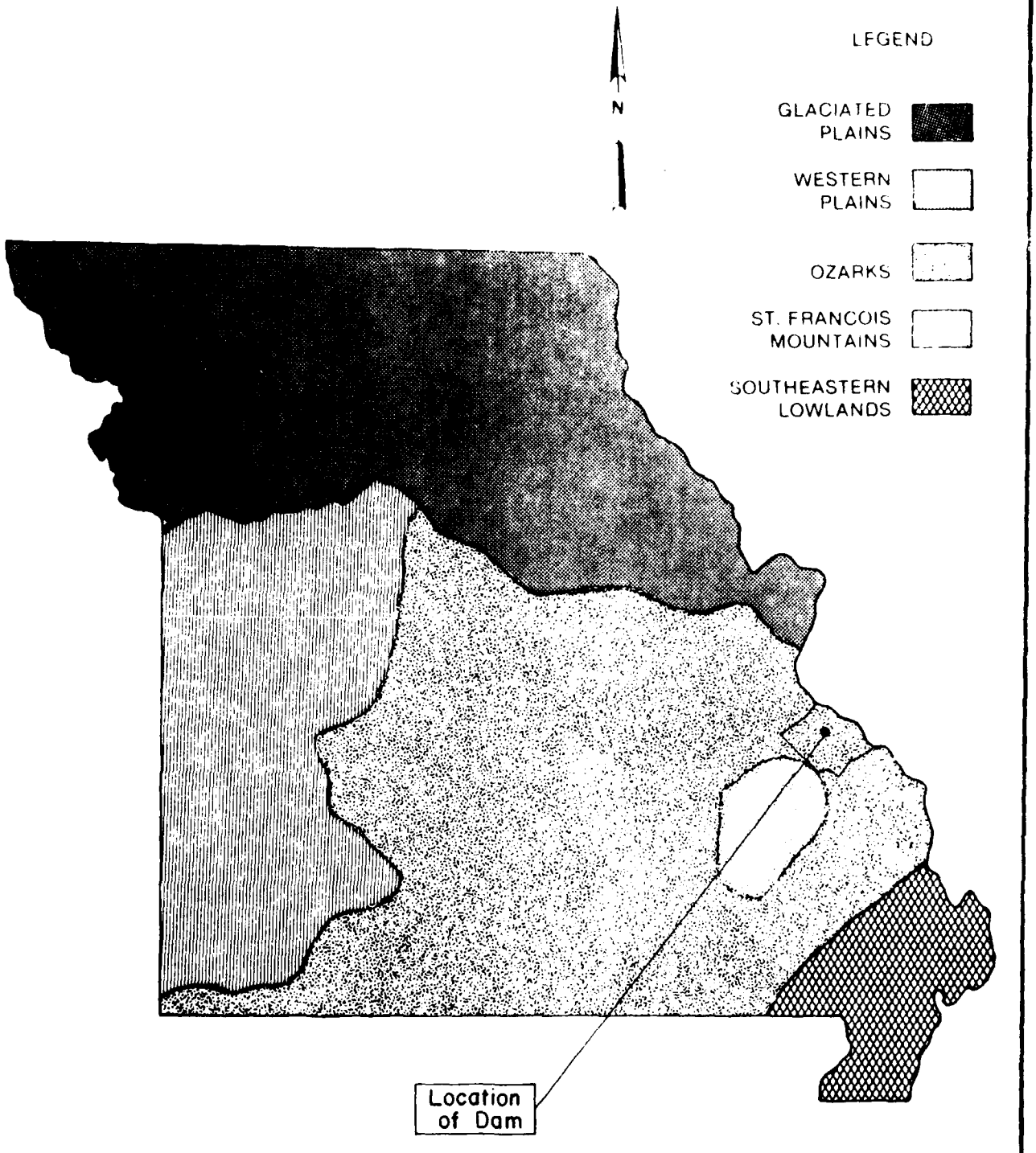
SHEET 4, APPENDIX A



A/E ANDERSON ENGINEERING, INC. 730 N BENTON AVE • SPRINGFIELD, MO. 65802	PLAN SKETCH OF DAM GOVRO LAKE DAM STE. GENEVIEVE COUNTY, MISSOURI MO. I. D. No. 31095 SHEET 5 , APPENDIX A

APPENDIX B

Geology and Soils



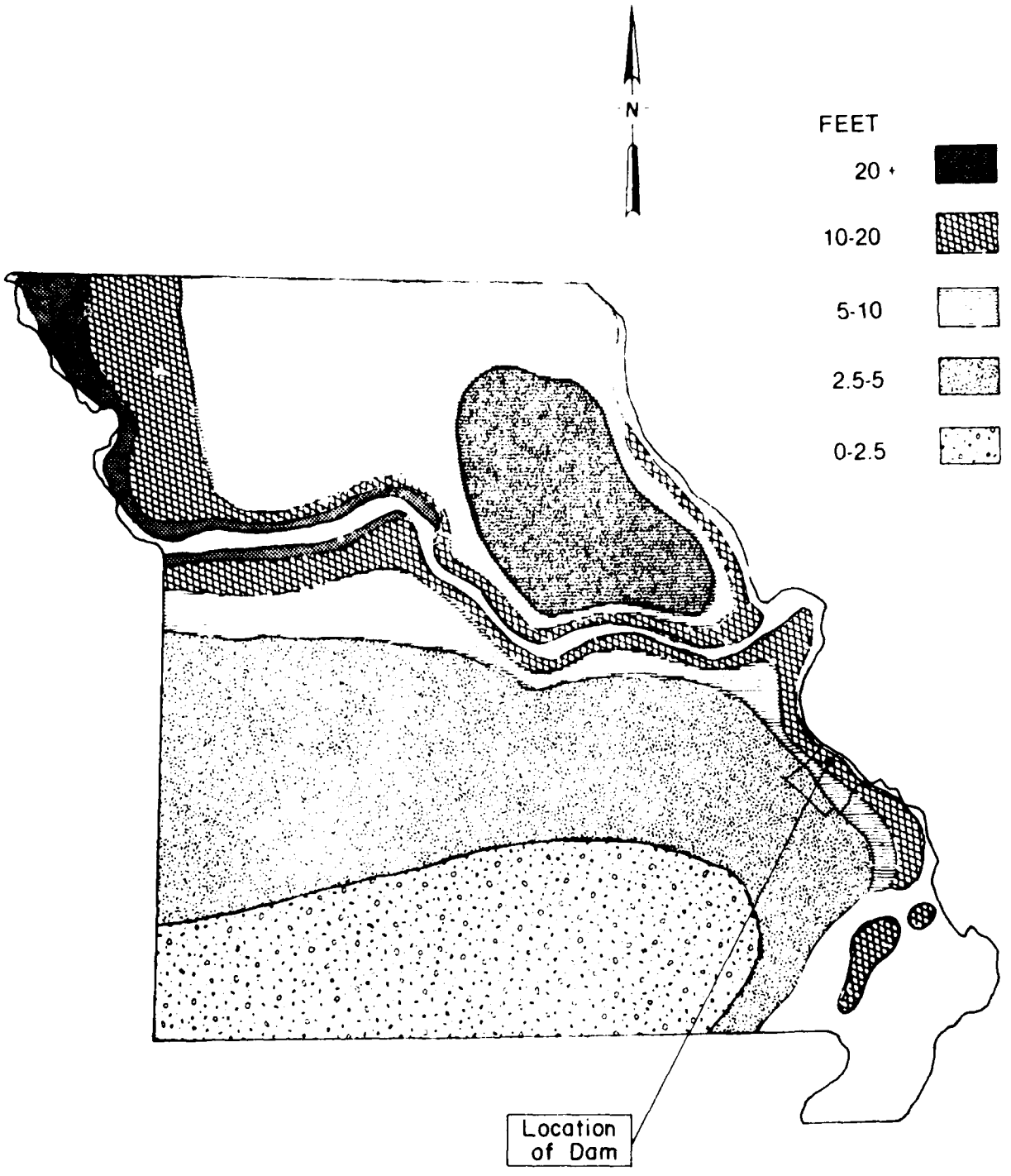
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Govro Lake Dam
St. Genevieve County, Missouri
Mo. I.D. No. 31095

SHEET 1, APPENDIX B



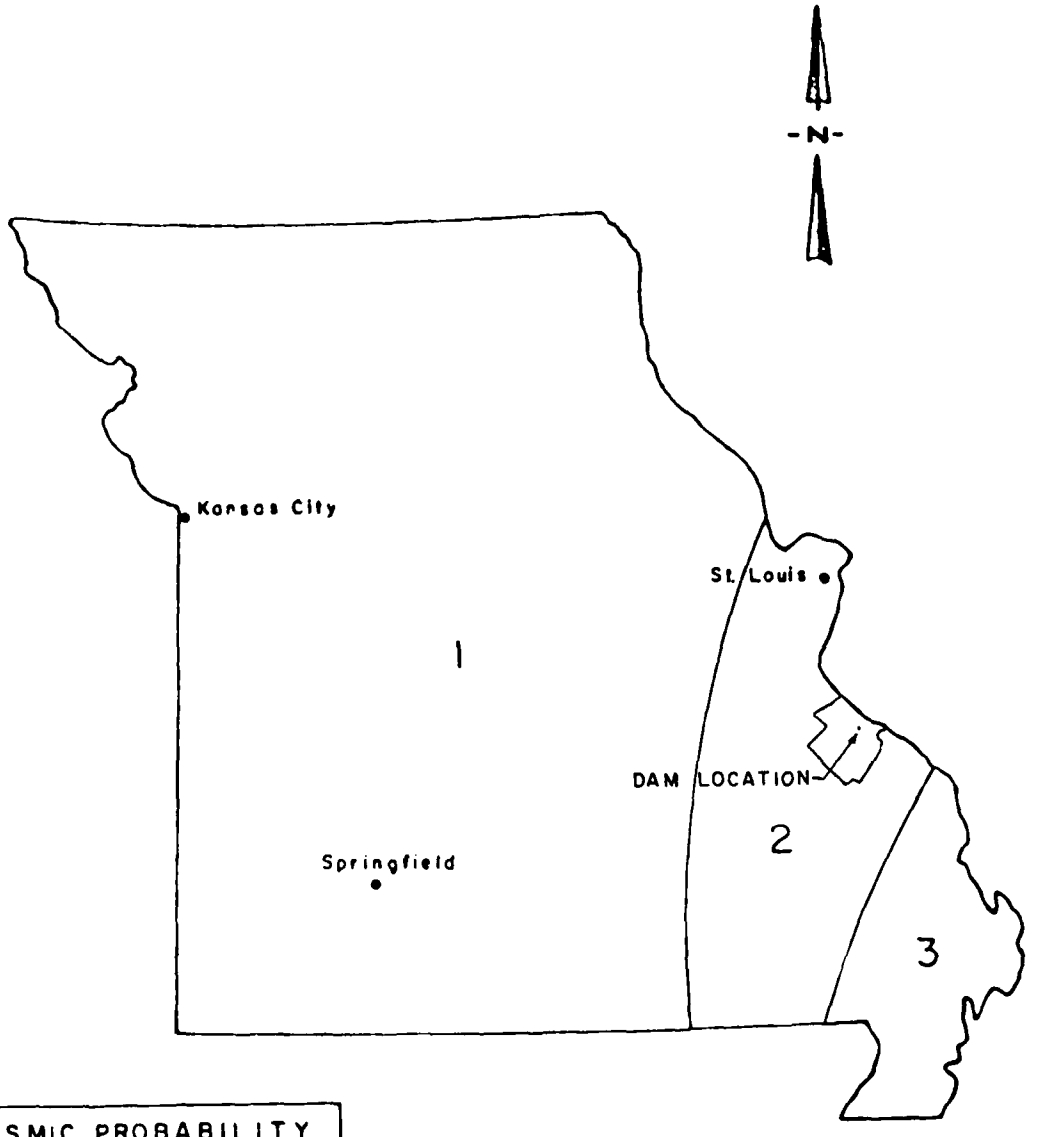
THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Govro Lake Dam
St. Genevieve County, Missouri
Mo. I.D. No. 31095

SHEET 2, APPENDIX B



SEISMIC PROBABILITY	
ZONE	DAMAGE
1	MINOR
2	MODERATE
3	MAJOR

A/E ANDERSON ENGINEERING, INC.
730 N. BENTON AVE • SPRINGFIELD, MO. 65802

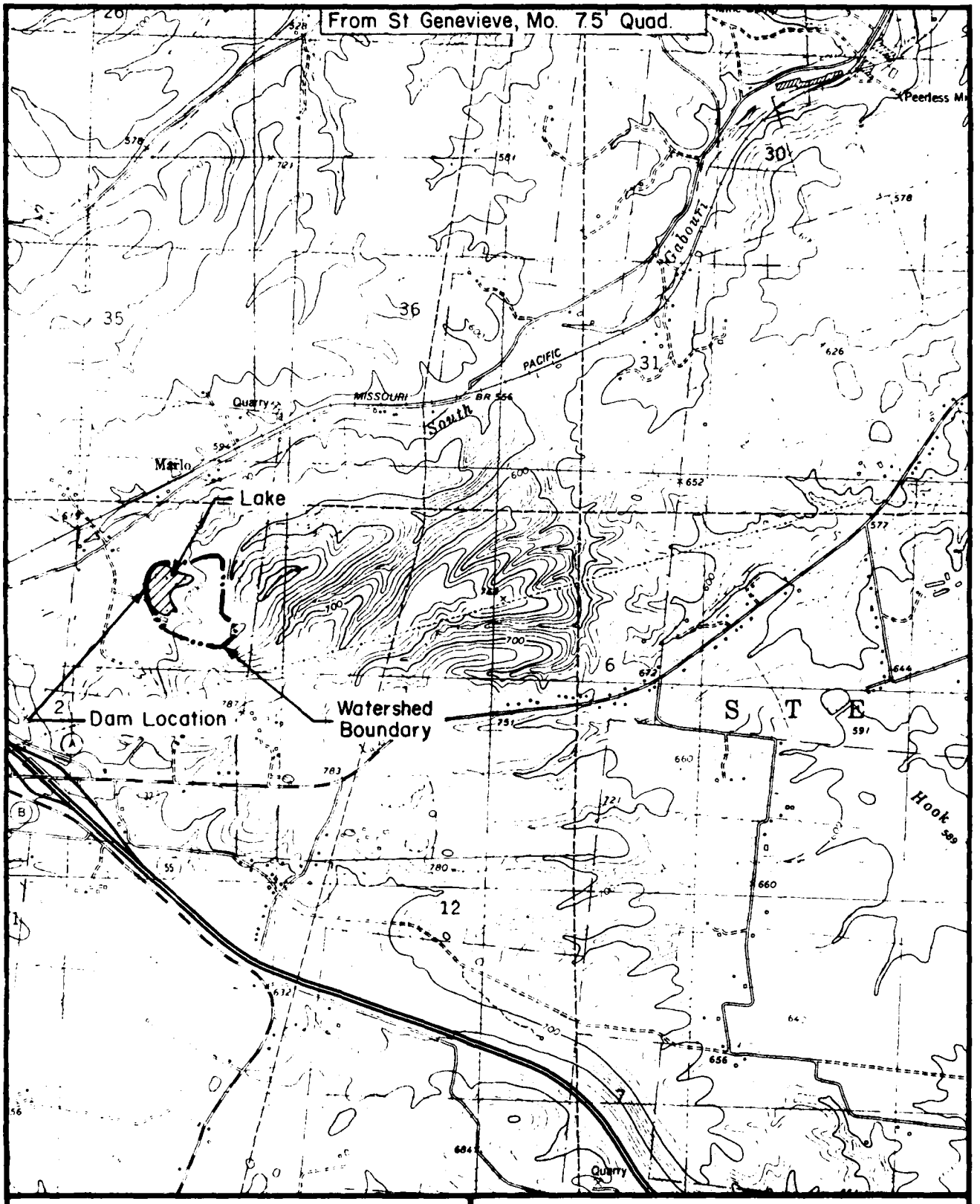
SEISMIC ZONE MAP

GOVRO LAKE DAM
STE. GENEVIEVE COUNTY, MISSOURI
MO. I. D. No. 31095

SHEET 3, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Govro Lake Dam
St. Genevieve County, Missouri
Mo. I.D. No. 31095

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination).

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The time of concentration was estimated using the Kirpich formula. This formula and the parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C). The time of concentration was also verified from velocity estimates for the average slopes of the watershed and the main channel (Design of Small Dams, page 70, 1974 Edition).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used for the antecedent moisture conditions (AMC), and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C). For the antecedent storms, AMC II was used.

The reservoir routing was accomplished by using the Modified Puls Method. Antecedent storms, assuming the starting reservoir elevation at the mean annual high water, were routed to determine the starting elevation for the major floods. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area-storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C).

The reservoir of this dam has never been filled because of leakage. To account for the effect of reservoir storage in the routing, an antecedent storm of 25 percent and 50 percent of the PMF was considered assuming the reservoir at elevation 646.6 (mean annual high water) to determine the starting reservoir elevation for the routing of 50 percent and 100 percent of the PMF respectively. The 25 percent PMF reached elevation 651.9, and the 50 percent PMF reached elevation 657.2. These antecedent storms were assumed to occur four days prior to to the corresponding storm. There are no outlet works or dewatering structures in this dam. The loss of storage during that time, due to leakage, was neglected. Thus, the final routing analysis was accomplished starting at elevation 657.2 for the PMF, and at elevation 651.9 for the 50 percent PMF storm.

The spillway crest elevation (667.6) in this dam is higher than the top of dam elevation (666.0). To run the HEC-1 computer program under this condition, only for the PMF (overtops the dam), the spillway crest elevation was assumed equal to the top of dam elevation (666.0), and the rating curve was adjusted as follows:

1) Discharge at elevation 666.0 = 0 cfs.

2) Discharge at elevation 667.6 = 1 cfs.

See cards Y4, Y5 and $$ on Sheet 10, Appendix C for clarification.

The percentage of the PMF that will reach the top of the dam was estimated to be 90 percent.

The rating curve for the spillway (see Table 4 Sheet 6, Appendix C) was determined assuming critical flow conditions on a trapozoidal broad-crested weir, and approach channel losses equal to 30 percent of the critical velocity head.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes ciritical flow over a broad-created weir. The lowest elevation of the crest of the dam, obtained from survey measurements, was assumed as top of dam elevation.

A summary of the routing analysis is shown in Table 5 (Sheet 7, Appendix C). The result of the routings indicates that the reservoir will store the 1 percent probability flood without reaching the top of the dam.

The computer input data and a summary of the output data for the antecedent storms and the PMF are presented on Sheets 8 through 11 of Appendix C. A plot of the inflow-outflow hydrograph for the PMF is shown on Sheet 12, Appendix C. The input data and a summary of the output data for 50 percent of the PMF are shown on Sheets 13 and 14 of Appendix C.

TABLE I

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.05 sq miles
Length of Watercourse (L)	0.27 miles
Difference in elevation (H)	153 ft
Time of concentration (Tc)	0.08 hrs
Lag Time (Lg)	0.05 hrs
Time to peak (Tp)	0.09 hrs
Peak Discharge (Qp)	270 cfs
Duration (D)	5 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	259
10	99
15	23
20	5
25	1
30	0

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

Kirpich Formula.
From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$

Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
Antecedent Storm:				
PMP (AMC II)	24	33.8	28.9	4.9
Final Routing:				
PMP (AMC III)	24	33.8	31.7	2.1

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 83 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 66 (AMC II) for the 1 percent probability flood
4) Percentage of Drainage Basin Impervious 10 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
626.0	0	0	-
640.0	1.5	11	-
646.6	1.6	25	-
660.0	5.1	77	-
**666.0	6.8	113	-
*667.6	7.2	125	0
670.0	7.9	142	255
680.0	10.7	-	-

*Principal spillway crest elevation (higher than the existing top of dam elevation)
**Top of dam elevation

The above relationships were developed using data from the USGS Ste. Genevieve, MO-IL 7.5 minute quadrangle map with a 20 ft contour interval, and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)
*667.6	0
668.0	8
668.5	35
669.0	85
669.5	155
670.0	255
670.5	400
670.9	540
671.0	580

*Principal spillway crest elevation.

Method Used: Assuming critical flow conditions on a trapezoidal broad-crested weir and approach channel losses equal to 30 percent of the critical velocity head.

Formula:

$\frac{Q^2}{g} = \frac{A^3}{T}$ Design of Small Dams, 1974 Edition, Page 553, Water and Power Resources Service (Formerly USBR).

Q = Discharge in cubic feet per second
A = Cross sectional area in square feet
T = Water surface width in feet
g = Acceleration of gravity in ft/sec

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft) Over Top of Dam
1) Antecedent Storms					
-	0	*646.6	25	0	0
0.25	220	651.9	46	0	0
0.50	440	657.2	66	0	0
1.00	880	665.1	107	0	0
2) Final Routing (PMF)					
-	0	*657.2	66	0	0
1.00	910	666.9	120	370	0.9
3) Final Routing (50 Percent PMF)					
-	0	*651.9	46	0	0
0.5	460	662.3	91	0	0

The percentage of the PMF that will reach the top of the dam was estimated to be 90 percent.

*Starting reservoir elevation used in each case of routing.

```
A       OVERTOPPING ANALYSIS FOR COVRO LAKE DAM ( # 2 ) (ANTECEDENT STORMS)
A       STATE ID NO. 31095  COUNTY NAME : ST. GENEVIEVE
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001
B    288                5
B1     5
J      1       3       1
J1   .25     .50     1.0
K      0       1                                  3       1
K1       INFLOW HYDROGRAPH COMPUTATION **
M      1       2    0.05            0.05       1                       1
P      0    26.0     102     120     130
T                                                      -1     -66             0.10
W2  0.08    0.05
X      0      -.1       2
K      1       2                          0       4       1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                       1       1
Y1     1                                                25      -1
Y4 667.6   668.0   668.5   669.0   669.5   670.0   670.5   670.9   671.0
Y5     0       8      35      85     155     255     400     540     580
$S     0      11      25      77     113     142
$E 626.0   640.0   646.6   660.0   666.0   670.0
$$ 667.6
$D 666.0
$L   100     250     280     380     400     420     625     820     850    1000
$V 666.0   667.3   667.5   667.5   667.6   667.7   668.3   668.6   668.7   669.3
K     99
```

25 AND 50 PERCENT PMF
ANTECEDENT STORMS
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS		
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3
				0.25	0.50	1.00
HYDROGRAPH AT	1	0.05	1	221.	441.	883.
	(	0.13)	(	6.25) (	12.50) (	25.00) (
ROUTED TO	2	0.05	1	0.	0.	0.
	(	0.13)	(	0.00) (	0.00) (	0.00) (

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	646.60	667.60	666.00
STORAGE	25.	125.	113.
OUTFLOW	0.	1073.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.25	651.89	0.00	46.	0.	0.00	0.00	0.00
0.50	657.20	0.00	66.	0.	0.00	0.00	0.00
1.00	665.06	0.00	107.	0.	0.00	0.00	0.00

25 AND 50 PERCENT PMF
ANTECEDENT STORMS
OUTPUT DATA

```
A       OVERTOPPING ANALYSIS FOR COVRO LAKE DAM ( # 2 ) (100 % PMF)
A       STATE ID NO. 31095  COUNTY NAME : ST. GENEVIEVE
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001
B    288                5
B1     5
J      1        1        1
J1   1.0
K      0        1                                  3        1
K1       INFLOW HYDROGRAPH COMPUTATION **
M      1        2     0.05              0.05       1                          1
P      0     26.0      102      120      130
T                                                          -1      -83              0.10
W2  0.08     0.05
X      0     -.1        2
K      1        2                                  2        4        1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                        1        1
Y1     1                                                          66       -1
Y4 666.0    667.6    668.0    668.5    669.0    669.5    670.0    670.5    670.9    671.0
Y5     0        1        8       35       85      155      255      400      540      580
$S     0       11       25       46       66       77      113      142
$E 626.0    640.0    646.6    651.9    657.2    660.0    666.0    670.0
$$ 666.0
$D 666.0
$L   100      250      280      380      400      420      625      820      850     1000
$V 666.0    667.3    667.5    667.5    667.6    667.7    668.3    668.6    668.7    669.3
K     99
```

PMF (INPUT DATA)

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

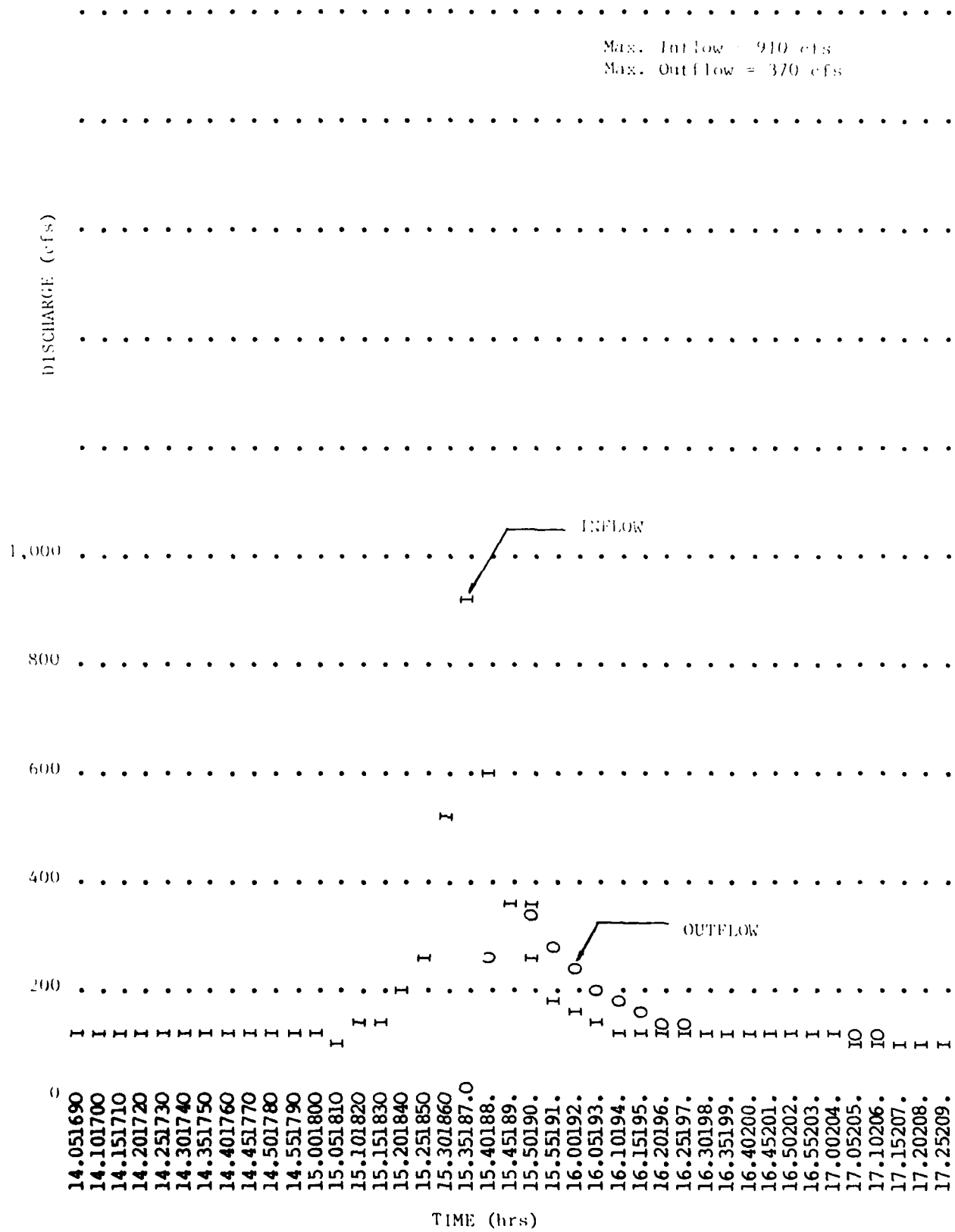
OPERATION	STATION	AREA	PLAN	RATIO 1
				1.00
HYDROGRAPH AT	1	0.05	1	912.
		(0.13)		(25.83) (
ROUTED TO	2	0.05	1	367.
		(0.13)		(10.39) (

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	657.20	666.00	666.00
STORAGE	66.	113.	113.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	666.90	0.90	120.	367.	8.50	15.75	0.00

PMF (OUTPUT DATA)



INFLOW-OUTFLOW HYDROGRAPH
FOR THE PMF

```
A       OVERTOPPING ANALYSIS FOR COVRO LAKE DAM ( # 2 ) (50 % PMF)
A       STATE ID NO. 31095  COUNTY NAME : ST. GENEVIEVE
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 81S3001
B    288                5
B1     5
J      1       1       1
J1   .50
K      0       1                                3       1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1       2    0.05            0.05        1                       1
P      0    26.0     102     120     130
T                                                       -1     -83             0.10
W2  0.08    0.05
X      0     -.1       2
K      1       2                          0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                  1       1
Y1     1                                                46      -1
Y4 667.6   668.0   668.5   669.0   669.5   670.0   670.5   670.9   671.0
Y5     0       8      35      85     155     255     400     540     580
$S     0      11      25      46      77     113     142
$E 626.0   640.0   646.6   651.9   660.0   666.0   670.0
$$ 667.6
$D 666.0
$L   100     250     280     380     400     420     625     820     850    1000
$V 666.0   667.3   667.5   667.5   667.6   667.7   668.3   668.6   668.7   669.3
K     99
```

50 PERCENT PMF
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1
				0.50
HYDROGRAPH AT	1	0.05	1	456.
	(	0.13)	(	12.91) (
ROUTED TO	2	0.05	1	0.
	(	0.13)	(	0.00) (

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	651.90	667.60	666.00
STORAGE	46.	125.	113.
OUTFLOW	0.	1073.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.50	662.33	0.00	91.	0.	0.00	0.00	0.00

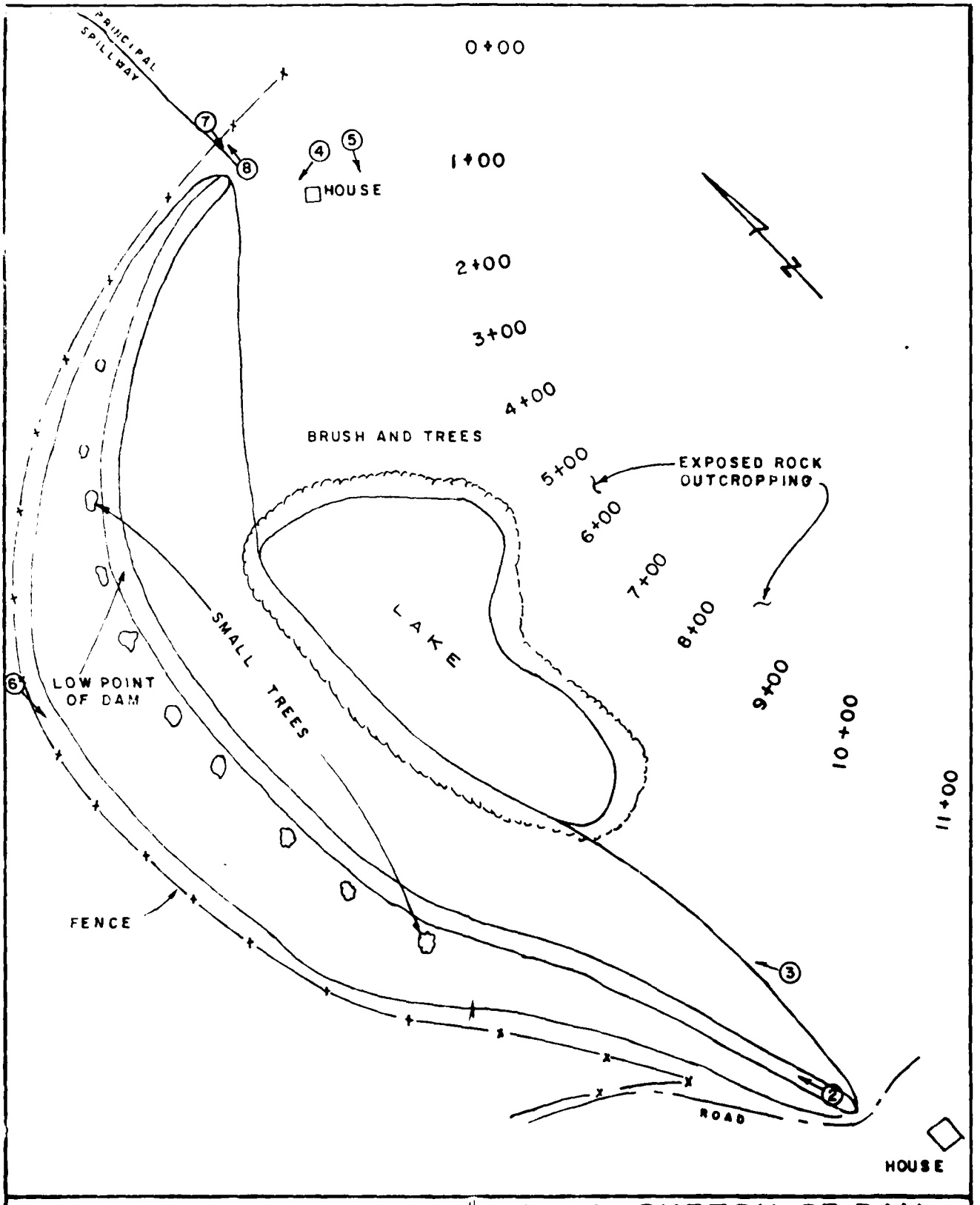
50 PERCENT PMF
OUTPUT DATA

APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

Photo No.	Description
1	Aerial view of Lake and Dam (looking East)
2	View of crest of embankment. Note brush and tree growth (looking North)
3	Upstream slope of embankment. Note tree growth (looking North)
4	Upstream slope of embankment near principal spillway. Note apparent low area of embankment and rock outcropping (looking West)
5	View of lake area (looking South)
6	Downstream slope of embankment. Note grass cover and scattered tree growth (looking South)
7	Principal spillway control section (looking South)
8	Principal spillway outlet channel (looking North)

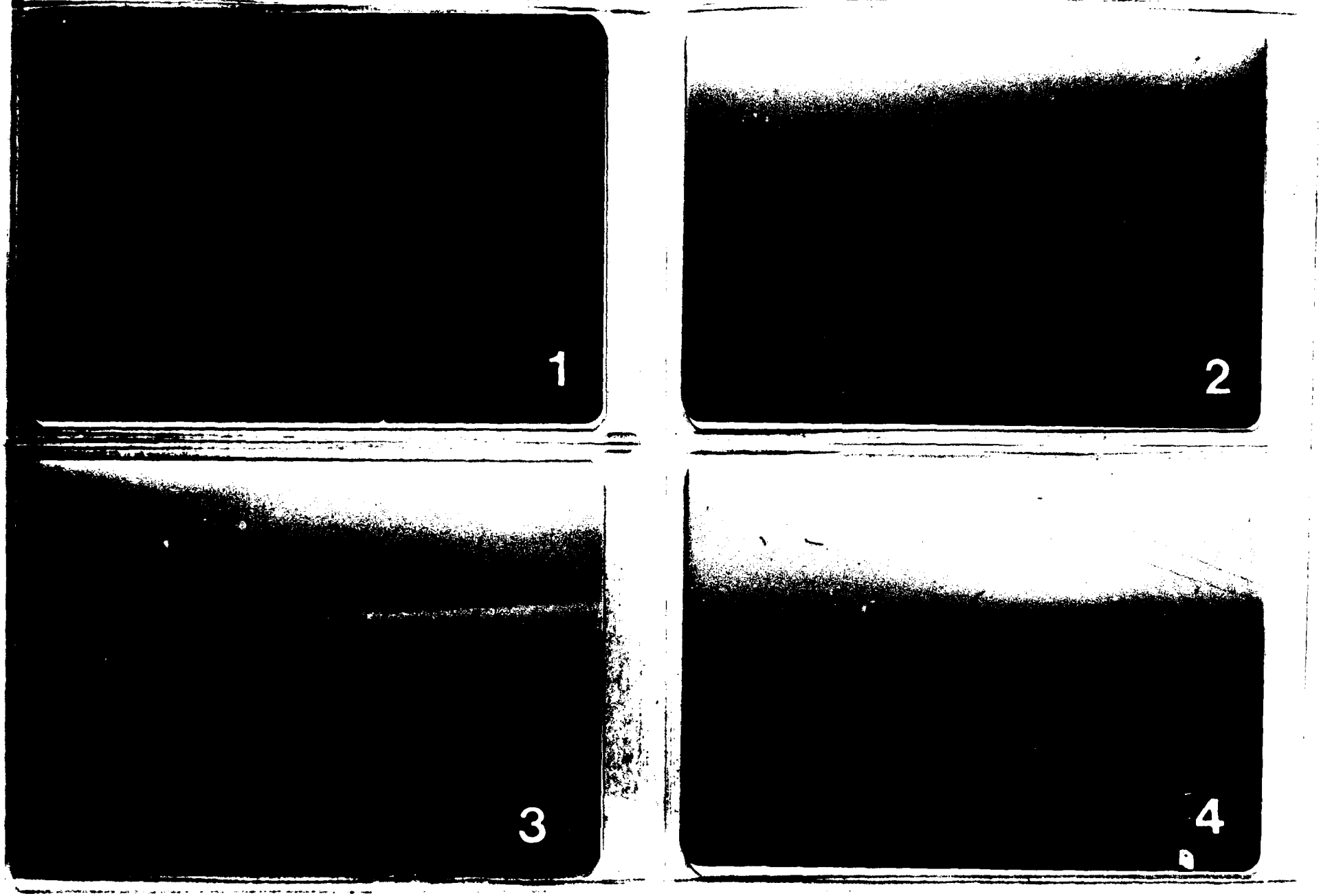


PLAN SKETCH OF DAM

GOVRO LAKE DAM
STE. GENEVIEVE COUNTY, MISSOURI
MO. I. D. No. 31095

SHEET 2 , APPENDIX D

A/E ANDERSON ENGINEERING, INC.
730 N BENTON AVE. • SPRINGFIELD, MO. 65802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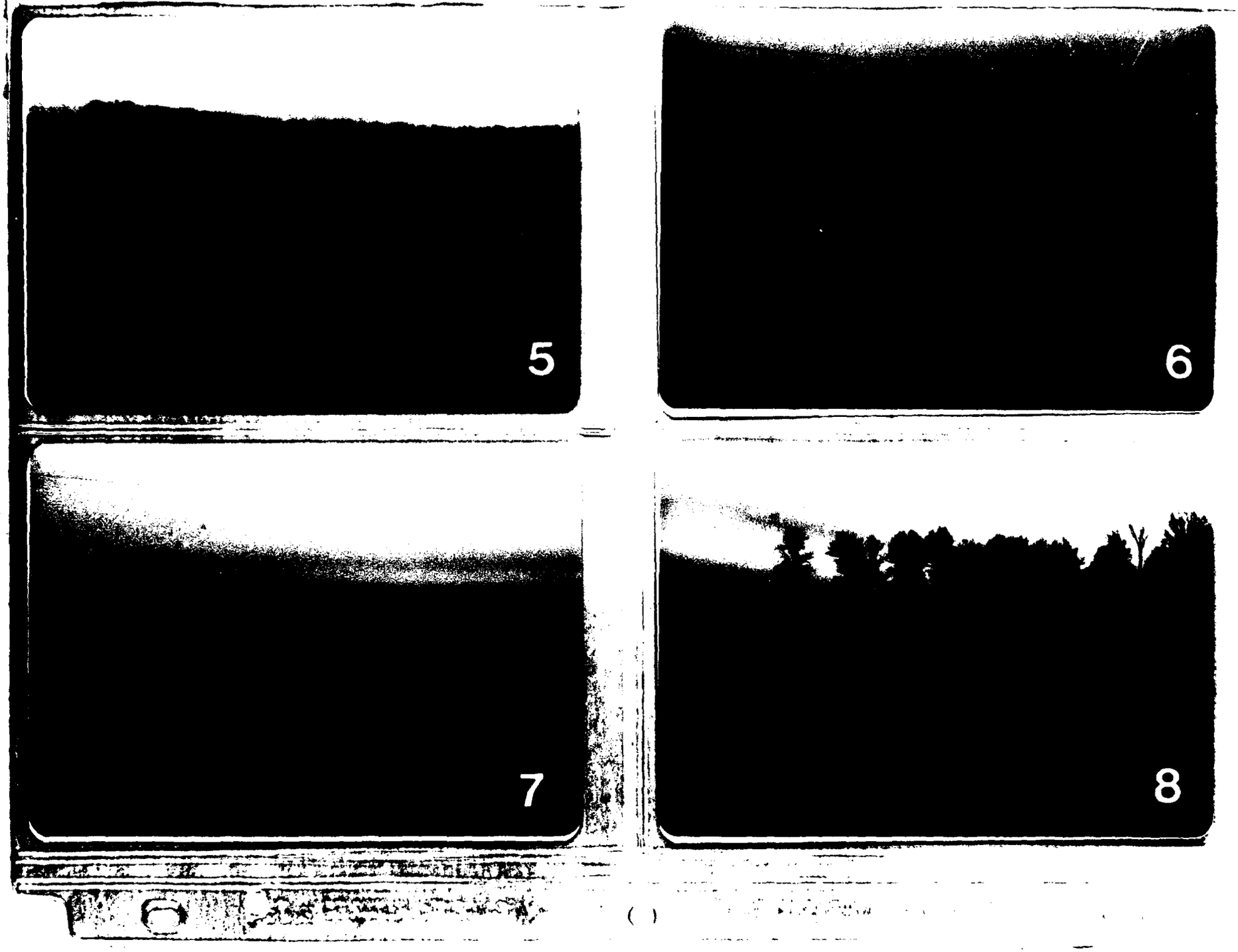
2
3
4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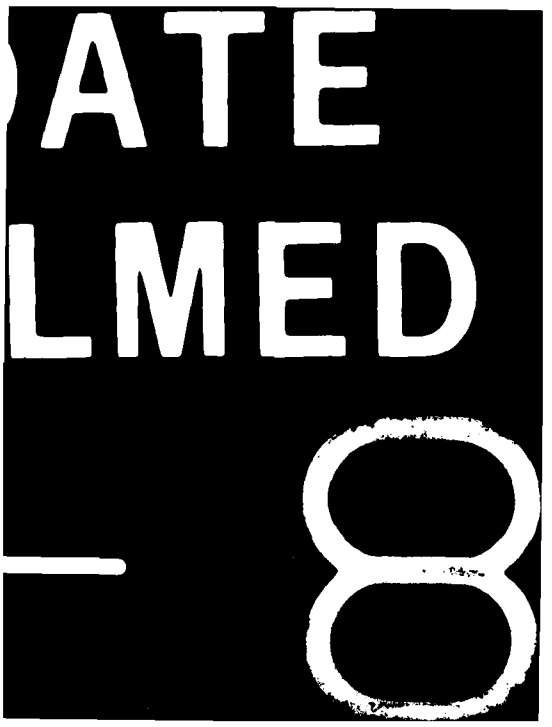
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